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PRODUCTION PLANNING FOR FURNITURE PLANTS*

Prepared by

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CONTENTS

		Page
1.	Introduction	1
2.	Objectives of planning	2
3.	Basic parameters for efficient production planning	2
4.	Production planning in a woodworking plant	5
5.	Manpower planning	8
6.	Planning of production materials, raw materials, and fittings for an unimpeded production flow	9
	Bibliography	9
	ANNEX 1	10
	ANNEX 2	11
	ANNEX 3	12
	ANNEX 4	13
	ANNEX 5	14
	ANNEX 6	15
	ANNEX 7	16

1. INTRODUCTION

The subject of production planning in wood processing enterprises discussed in this paper outlines experience and application of a planning strategy in a very flexible and vital small-size woodworking plant. Theoretical assumptions have been the basis of planning methods presented herein.

The small woodworking plant taken as an example employs 80 persons and manufactures case goods and solid wood furniture; a large proportion of the output is exported to hard currency markets. The planning approach practiced in the plant is very efficient, yet simple and logical. It should be noted that the staff of the plant alone do not produce all data required for their production planning, nor information on other factors that have an influence on unimpeded production flows; in this task they are assisted by experts from various departments in the head office. This fact, however, has hardly any impact upon the topic of our discussion, and the paper will show that all relevant data must be compiled and processed within the production management process in the plant itself.

This paper does not cover production planning alone; it also deals with the planning of all other parallel parameters without which the planning of profitable production simply cannot be made. Once all activities organized within a plant are fully compatible, and no down-time will result from their interactions, unimpeded and probably viable production can be expected. The next pages will define such activities and all relevant parameters.

The legislation in Yugoslavia stipulates that each enterprise must elaborate a long-term and a mid-term development programme. The long-term is a rather strategic development programme; the mid-term development programme, on the other hand, contains some production indicators for a five-year period. The annual management programme is very detailed and includes the production plan; quarterly plans are even more detailed, and the monthly, weekly, and daily production programmes are extremely detailed.

2. OBJECTIVES OF PLANNING

A fundamental objective of all production planning, including that of a wood processing plant, is the manufacturing of a maximum volume of products having the quality that the market requires and, consequently absorbs, whereby exisitng, or programmed output capacities are taken into account, i.e. the capacity of a given plant.

No professional and expert management decisions can be made without planning. Unless plans and programmes are made, i.e. calculations, in the very first stage of preparations for decision-making in management and business terms, one cannot select the right product for one's market, and one will not know whether production of the selected product will be profitable or not, nor will one know what machinery should be procured, nor what other conditions must be met prior to production planning, to secure consequently a normal production flow. For these reasons the paper briefly touches upon materials planning, the planning of required power and other facilities that must be controlled prior to production.

In terms of planning objectives, two categories of planning may be defined: general planning and detailed planning. When elaborating long-term, mid-term and annual plans, and this also applies to quarterly programmes, general planning is involved; monthly, weekly, and daily planning, on the other hand, is a detailed planning process.

3. BASIC PARAMETERS FOR EFFICIENT PRODUCTION PLANNING

The initial state of affairs must first be defined. In our specific case a new type of production is planned; at the same time, however, planning in an existing furniture plant will also be elucidated for the technology of manufacturing of casegoods and solid wood furniture. The initial input data is as follows:

(a) The technological process of casegoods' production.

(b) The technological process of solid wood furniture production.

The knowledge of a technological process of production implies knowledge of a set of machines, of all operations that the machines can perform, and the knowledge of handling and transportation from one machine to the other.

Fully unknown at this stage are capacities of individual machines, and even more so of the plant as a whole which can only be determined once the product(s) to be made is defined, how production will proceed, what tools will be used, who will work in the plant, and what volume as well as quantity of the produc(s) the market demands.

Once the marketing department has defined the products, whose quality and price have also been defined, an approximative planning process can begin; the purpose of this process is two-fold:

(a) To answer the question whether it is possible at all to manufacture the suggested product(s) in the required quantities and on a profitable basis.

(b) To have at least the general data required to approach as soon as possible the preparation of the production and the manufacture of the selected product(s).

The following data are indispensable for the detailed planning of a production:

(a) A detailed description of the product, i.e. form, function, type of built-in materials and fittings, type of surface treatment, packaging mode defined by means of transport and/or shipment, particularly in case of overseas transportation.

(b) A detailed drawing of the product, including dimensions.

(c) Material lists for each component of the product, including its dimensions.

(d) A description of the consecutive operations for each element of the product separately, and the number of workers required for each individual operation.

(e) Standard times for each operation (until a method of work and time standards according to either REFA or WF methods has been introduced, empirical operation times are applied).

(f) Non-production times, i.e. the time of preparation and completion of work, time required for machine preparation, waiting times when something is not yet ready, etc; in other words justifiable organizational losses must be defined.

(g) Time required for one's needs and break time.

Annex 1 gives an example of a perfectly elaborated and complete materials list. Unfortunately this is not enough; other data is also required. For determining the output capacity of a machine or a production line, i.e. plant production flow, the following data must also be available:

(a) A list of all the installed machines.

(b) A description of every machine in terms of its technological capacity and output capacity, i.e.:

(i) A description and a list of the operation(s) that the machine can perform.

(ii) The feed speed of each operation (from minimum to maximum speed); the knowledge of that particular industrial branch will then be decisive when choosing an adequate feed speed for the machining selected.

(iii) The type of motors and their power in kw.

(iv) The dust removal technology, a description of the exhaust points, the exhaust tube diameter and the air speed.

(v) A description of the coupling points for compressed air and consumption of compression air at each point.

(vi) Points for the removal of polluted water and the quantity of water eliminated at each of the points.

(vii) A description and a list of machines and devices that must be heated, including heat consumption for each.

(viii) A list of tools that are available, i.e. circular saw blades, planing knives, cutting tools, machining heads, borers, sanding discs, sanding paper, etc.

(ix) The lubrication requirements of the machine: oiling points, oiling frequency, oiling instructions, and instructions for maintenance.

(x) Machine protection in terms of work safety, and safety instructions.

It is necessary also to collect data and information concerning the envisaged stock of each material separately, and a description of transport and handling methods proposed to be used. All these (and possibly other) parameters will allow one to approach production planning and the planning of all other quantities and indicators that are indispensable for the monitoring of the operation of a plant.

4. PRODUCTION PLANNING IN A WOODWORKING PLANT

Production can be planned in a woodworking plant once its capacity is determined for a specific product or product group. Two products have been selected for the sake of illustrating production planning:

(a) A bedside chest, made in oak veneer on particle board, with three drawers, without legs; the surfaces are treated with a polyurethane lacquer; one set of chests is made in the veneer's natural colour, and the other with previously stained veneer.

(b) A mosaic parquet overlayed table top, made primarily of solid wood, the supporting board being made of particle board, then covered with mosaic parquet blocks, solid wood edge strips, and a thin fibre board on the under side; the table top is surface treated by acid catalysed lacquer and previously stained.

The sequence of operations is as follows:

(a) The marketing and/or sales department furnishes basic data about the product, such as:

(i) A detailed and exact description in a manner similar to that above.

(ii) A design or at least a drawing or photograph of the product, when nothing more than a photograph or an approximate drawing is available; a team of an interior designer, a technology expert, and a designer must develop the final proposal that can, in principle, be manufactured with available technology and machinery.

(b) The plant's technical preparation department must prepare the materials lists. See Annex 1.

(c) The technological preparation department must develop the technological process for each element separately; it should include every single operation; all operations are then inserted into operations sequence lists in their real sequence. See Annex 2.

(d) The time study department - or an expert of the plant in charge of time and other standards - then determines the technological standard times and auxiliary times are then added and standard production times can be obtained, to which the preparation and completion times are finally added, along with justifiable organizational time losses. See Annex 3. Standard times obtained in this manner for each operation are then added to the description of each operation in the operations sequence lists. See Annex 2.

(e) Before calculations of the capacity of each machine are initiated, the available working time per day, i.e. in one shift, must also be determined. In Yugoslavia working hours are defined by law: the 8 hours working time per day includes a 30 minute break and 20 more minutes for personal needs. Of 480 minutes of working time per day, only 430 minutes are actually available.

Experience, on the other hand, shows that up to a maximum of 60 minutes should also be considered every day for organization-related time losses that cannot be foreseen, such as machine breakdowns, power cuts, waiting for materials or a means of transportation, unenvisaged blades substitutions, etc. When the organization-related time loss is statistically reliable, it must be deducted from the available work time: 430 minutes - 60 minutes = 370 minutes prior to planning shift working time.

(f) Once all the necessary elements have been determined, calculations of an individual machine's performance rates can be made. First, all identical or similar operations for one product are added (of one batch, e.g.: 100 bedside chests) and inserted into a separate operations list and list of standard times. See Annex 4. For the second product the same is made, and a total number of operations is included in individual machine columns of the same list.

Once all trimming operations are added in the materials lists the standard time for all board trimmings amounts to 2.50 minutes.

The next point to be defined is the capacity of the trimming machine for all parquet table elements. Dividing the available time of 370 minutes by 2.50 minutes, 148 is obtained. This is the number of tables that can be trimmed per day on this machine. The same calculations are made for each product, i.e. for the bedside chest and the table.

An analysis of such performance rates indicates that more or less than the desired number of elements for bedside chests can be manufactured in a specific operation, or that a minimum of elements for parquet tables can be manufactured in another operation. The minimum capacity point is the bottleneck and it determines the output capacity of the entire production lines. When the bottleneck can be eliminated by a minor investment, which will result in increased output capacity, this should certainly be made. If not, careful calculations must be made, and possibly the second and third shift introduced for this specific machine.

Output capacity of one shift has thus been calculated. It is known that, e.g. 62 bedside chests or 30 tables can be made. This is the moment of a true chance to talk to commercial experts and decide about the number of bedside chests and tables to be manufactured and sold. An economic cost/benefit calculation will, as a rule, determine the ratio.

In practical terms activities outlined until this point should be considered part of the calculations prior to the finalization of offers and the signing of the contracts. In such a case standard times are not definitive, yet they should be rather accurate.

(g) Daily production planning. Once the ratio of products manufactured and sold has been determined (e.g. 50 bedside chests, the rest table tops, i.e. priority is given to the bedside chests) the planning of each operation for each machine should be started. This is done separately for the 1st and 2nd shift (see Annex 5). Operation times

for a product or an assignment are indicated by broken or unbroken lines. A graph obtained in this manner will illustrate daily outputs very accurately. This graph indicates exactly when changes are made in machines, and it serves to define the sequence of operations for all machines.

(b) A detailed plan of this type is produced for a whole week. Obviously it should be screened on a daily basis and modified to reflect reality whereby operations are shifted forward or backward. A plan of this sort can be shown on a special wall board for production management whereon magnetic discs or cardboard signs are used to indicate assignments and operations. See Annex 6 (similarly to Annex 5 broken and unbroken lines and also lines of dots are used to indicate times).

A monthly production plan is a sum total of 4 detailed weekly production plans; and delays, or outputs that have been accomplished ahead of scheduled time, must be permanently monitored and accounted for. Whenever delays have occurred, the remaining tasks should be incorporated into the plan of the next month's first week.

5. MANPOWER PLANNING

If standard times have been defined conscientiously and expertly for all operations, the sum total of all times for all products that the plant can manufacture will give the total required time, expressed in hours of work. When these are divided by 370 minutes the number of required workers will be obtained. Let it be emphasized that this is a relatively accurate number of production workers; usually additional workers required for auxiliary operations are calculated separately, i.e. those for maintenance, warehousing, handling and transportation, cleaning, canteen and, obviously, the production and plant management.

6. PLANNING OF PRODUCTION MATERIALS, RAW MATERIALS, AND FITTINGS FOR AN UNIMPEDED PRODUCTION FLOW

Basic documents required for the planning of fundamental raw materials and production materials are as follows: description of product, product design, materials lists, descriptions of technological processes (mechanical and surface treatment, assemblage, packaging, etc.). These data allow one to produce the most detailed materials lists in which all materials are defined, including type of material, its trademark, quality standard, dimensions, and total quantity required for one batch. Batches differ from each other, but in mass production they usually refer to 50, 100, 200 or 1,000 pieces and more.

The materials planner must be a good expert, both in terms of wood-working as well as knowledge of materials and the market. The best quality material available at the best price must be selected and planned, for which no supply and delivery problems are likely to crop up. Priority should be given to domestic materials so as to avoid imports and problems, as well as costs related to them.

Materials plans must be completed 2 to 3 months prior to full-scale operation, which will give the procurement department an opportunity and chance to organize the procurement of the required materials in a rational and viable manner, in terms of their quantity and quality.

Annex 7 shows a "Layout of plant for producing the items taken as examples".

BIBLIOGRAPHY

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ANNEX 1

Firm	Plant	MATERIALS LIST				Design: C-560	
		Product: Table top, P-60				Pcs: 1	
Material Code	NAME OF MATERIAL	Unit of measure	Net planned quantity	% extra	gross pl. quant.	Price per Unit	Total Price
003244	Particle board	m^2	1,20	15	1,38	326,oo	449,88
003301	Fibre board	m^2	1,20	8	1,30	153,oo	198,9o
003475	Mosaic parquet	m^2	1,20	2	1,22	450,00	549,oo
012815	Wooden edge lippings	m`	4,54	7	4,86	71,00	344,90
003186	Wooden dowels 20 x 12	pcs.	20	3	20,60	0,60	12,36
008466	Screws 55 x 50	pcs.	20	3	20,60	1,00	20,60
004689	Glue	kg	1,10	3	1,04	225,00	234,07
004762	Putty I	kg	0,05	10	0,055	15,00	0,82
004788	Putty II	kg	0,01	10	0,011	780,00	8,58
005058	Buck- water	kg	0,70	10	0,77	400,00	308,00
005306	Priming varnish	kg	0,20	10	0,22	146,00	32,12
006304	Sanding paper	m^2	0,10	3	0,103	160,00	16,48
005348	Mat - varnish	kg	0,16	10	0,176	270,00	47,52
005124	Solvent	kg	0,40	10	0,404	292,00	117,97
005678	Rags	m^2	0,12	10	0,132	116,00	15,31
007112	Packaging cardboard	m^2	2,88	3	2,97	26,00	77,13
007122	Adhesive tape	m`	3,60	2	3,67	2,00	7,34
	Total per piece:						2440,98

ANNEX 2

STANDARD MACHINING TIMES PER UNIT OF PRODUCTION FOR BASIC MACHINES

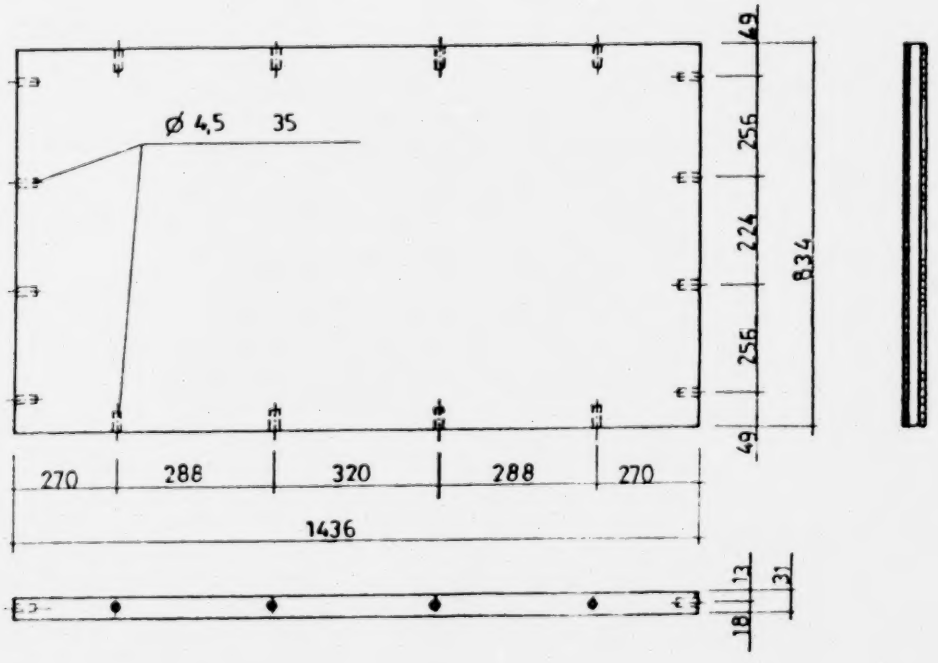
Code	Machine	Processing unit	Processing time in minutes
1.	Veneer clipper	M^2	2.02
2.	Veneer splicing machine	M^2	1.22
8.	Trimming saw	M	0.35
15.	Spindle moulder	M	0.27
18.	Dowel hole boring machine	Piece	2.07
21.	Veneering press	M^2	4.13
22.	Double end tenoner	M	0.25
23.	Edge banding machine	M	0.65
24.	Contact sander	M^2	0.50
26.	Belt sander	M^2	2.04
14.a	Spraying booth	M^3	1.14
16.k	Lacquering line	M^2	0.57
r.d.	Manual work	For piece	
	including assembly	Bedside chest	36.37

ANNEX 3

Firm	Technical work preparations	Operations sequence and standard times list			No.: 0-560
Element:	Table top with mosaic parquet overlay, P-60				For: 1 pc
Type of materials:	1. Chipboard, 20 mm 2. Fibreboard, 3 mm 3. Parquet blocks, 8 mm	Dimensions mm Gross Final	Length 1455 1436	Width 855 834	Thickness 31 31

Operation		Machine	Workers	Oper. std. t.	Total time
1.	Rough chipboard trimming - lateral	8	2	0.82	1.64
2.	Rough chipboard trimming - lengthwise	8	2	0.68	1.36
3.	Rough fibreboard trimming - lateral	8	2	1.38	2.76
4.	Rough fibreboard trimming - lengthwise	8	2	0.95	1.90
5.	Gluing of fibreboard onto chipboard	21	2	1.22	2.44
6.	Gluing of parquet onto chipboard	21	2	11.00	22.00
7.	Final board trimming - lateral	22	2	1.38	2.76
8.	Final board trimming - lengthwise	22	2	0.95	1.90
9.	Sanding of boards - parquet side	24	3	0.60	1.80
10.	Dowel-hole boring for string	18	2	1.92	3.84
11.	Gluing of strips to edges	(15)	2	9.00	18.00
12.	Milling-board edge rounding	15	2	2.76	5.52
13.	Table edge sanding	26	2	6.28	12.56
14.	Parquet surface (sealing)	(26)	2	3.00	6.00
15.	Final parquet surface sanding	26	2	4.42	8.84
16.	Board staining	14n	2	4.73	9.46
17.	Lacquering - lacquer base spraying	14n	2	2.85	5.70
18.	Intermediate lacquer sanding	6n	2	1.20	2.40
19.	Final board lacquering	14n	2	2.85	5.70
			39	57.99	115.98

Jig No.		Special warning
Blade No.	Boring bit No.: 15	Export quality
Scale	Milling tool No.:	



ANNEX 4

LIST OF PRODUCTION TIMES ON INDIVIDUAL MACHINES, FOR ELEMENT AND PRODUCT

Element - Machine code	1	2	8	15	18	21	22	23	24	26	14n	16n	r.d.
Chipboard	-	-	1.50	-	-	-	-	-	-	-	-	-	-
Fibreboard	-	-	2.33	-	-	-	-	-	-	-	-	-	-
Table top	-	-	-	2.76	1.92	12.22	2.50	-	0.60	10.70	10.43	1.20	7.84
Total for table top, P-60	-	-	3.83	2.76	1.92	12.22	2.50	-	0.60	10.70	10.43	1.20	7.84
Bedside chest top board	-	-	-	-	-	0.91	0.74	-	0.95	0.62	0.26	0.64	3.32
L + R sideboards (2 pcs)	1.32	1.72	-	-	4.14	1.82	1.14	3.04	2.20	0.98	0.38	1.28	8.90
Bottom	-	-	-	-	0.95	-	0.53	-	-	-	-	-	-
Drawer front board	0.48	0.48	-	0.35	0.57	0.32	0.20	1.91	0.92	0.62	0.29	0.88	5.36
Baseboard	0.17	0.17	-	0.14	0.33	0.36	0.23	0.72	-	0.51	-	0.36	0.91
Endboard	-	-	-	-	-	-	0.64	-	-	-	-	-	-
Drawer bottom	-	-	-	-	-	-	0.52	-	-	0.12	-	-	-
Chest assemblage & packaging	-	-	-	-	-	-	-	-	-	-	-	-	15.47
Total for BNN-5 bedside chest	1.97	2.37	-	0.49	5.99	3.41	4.00	5.62	4.07	2.85	0.85	3.16	33.96

Bottleneck for table top 12.22 Veneering press
Bottleneck for bedside chest 5.99 Dowel hole boring machine

Daily input in 1st shift: Table tops: 370 minutes : 12.22 = 30 pcs
or Bedside chests: 370 minutes : 5.99 = 62 pcs

In view of the biggest bottleneck in the veneering press, 50 bedside chests with pressing time = 170.5 minutes
and 16 tables with pressing time = 199.5 minutes

can be manufactured in one shift.

ANNEX 5

May: Table b. P60 ——— ; Bedside chests BNN5 — — — —

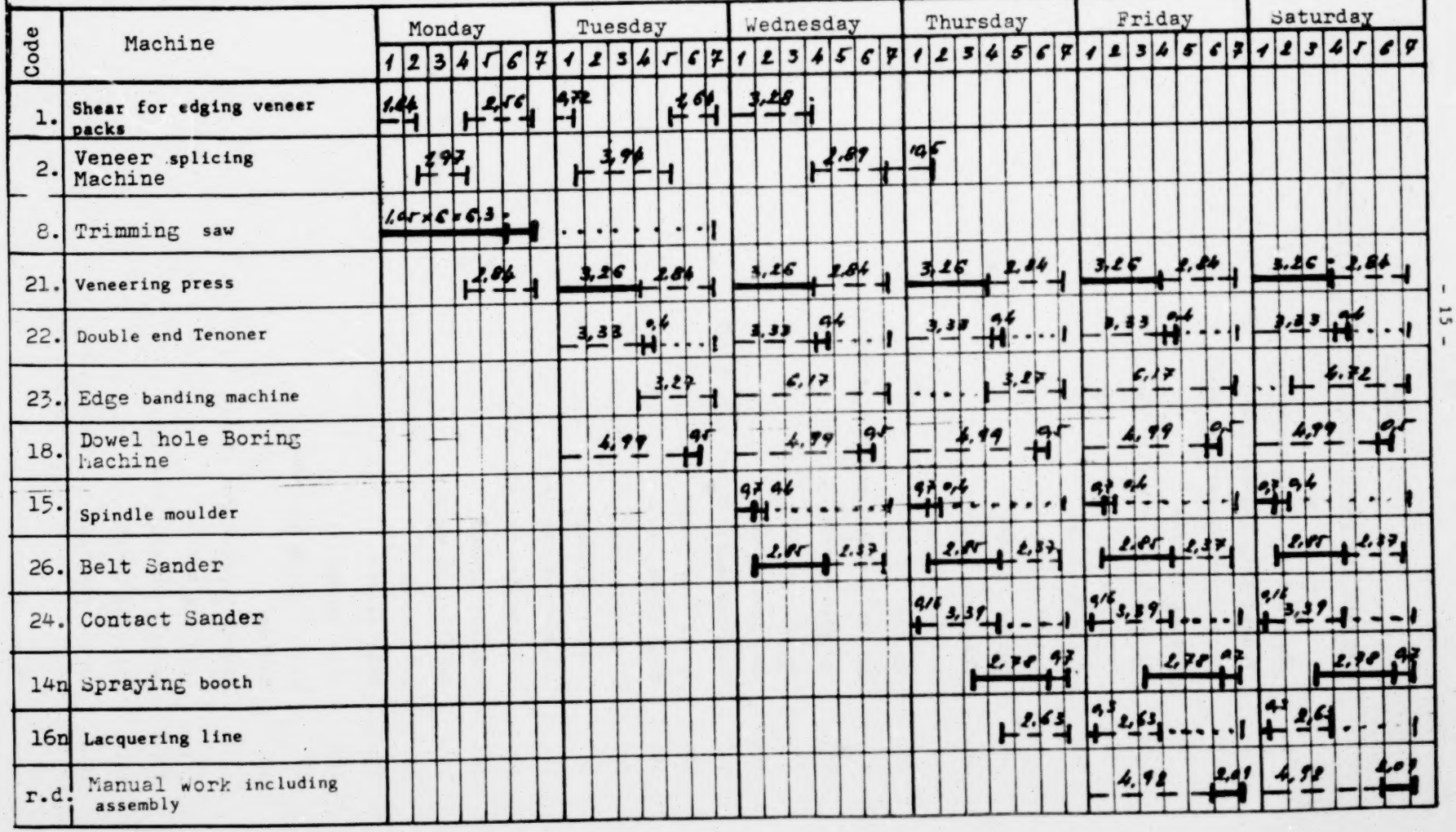
Daily production plan per machine for an assignment of 16 pcs Table tops
50 pcs Bedside chests

	Machine	Monday 1 st Shift							Utilr. %
		1. hour	2.	3.	4.	5.	6.	7.	
1.	Shear for edging veneer packs	1,97 min × 50 pcs = 1,64 h							26,6
2.	Veneer splicing machine	2,37 min × 50 pcs = 1,97 h							31,9
8.	Trimming saw	3,83 : 16 = 1,02 h							16,5
21.	Veneering press	12,22 min × 16 pcs = 195,52 min = 3,26 h			3,41 min × 50 pcs = 170,5 min = 2,84 h				100
22.	Double end Tenoner	0,66 h	4,00 min × 50 pcs = 200 min = 3,33 h						64,7
23.	Edge banding machine		5,67 min × 50 pcs = 283,50 min = 4,72 h						76,5
18.	Dowel hole Boring Mach.	0,51 h		5,99 min × 50 pcs = 299,5 min = 4,99 h					89,2
15.	Spindle moulder	0,78 h	0,4 h						18,3
26.	Belt Sander	10,70 min × 16 pcs = 171,20 min = 2,85 h			2,85 min × 50 pcs = 142,5 min = 2,37 h				84,6
24.	Contact Sander	0,16 h	4,07 min × 50 pcs = 203,50 min = 3,39 h						57,6
14n	Spraying booth	10,43 min × 16 pcs = 166,88 min = 2,78 h			0,70 h				56,4
16n	Lacquering line	0,32 h	3,16 min × 50 pcs = 158,00 min = 2,63 h						47,8
r.d.	Manual Work including assembly	7,84 min × 16 pcs = 125,44 min = 2,09 h		33,96 min × 50 pcs = 169,8 min = 2,83 h			Σ 30,39 h : 6,17 = 4,92 h		100
		In 6,17 A	5 Workers						

ANNEX 6

May: Table board P60 ——— , Bedside cheste BNN5 — — —, Other programe • • • •

Weekly production plan per machines for an assigument of 16 pcs Table tops
50 pcs Bedside chests



ANNEX 7

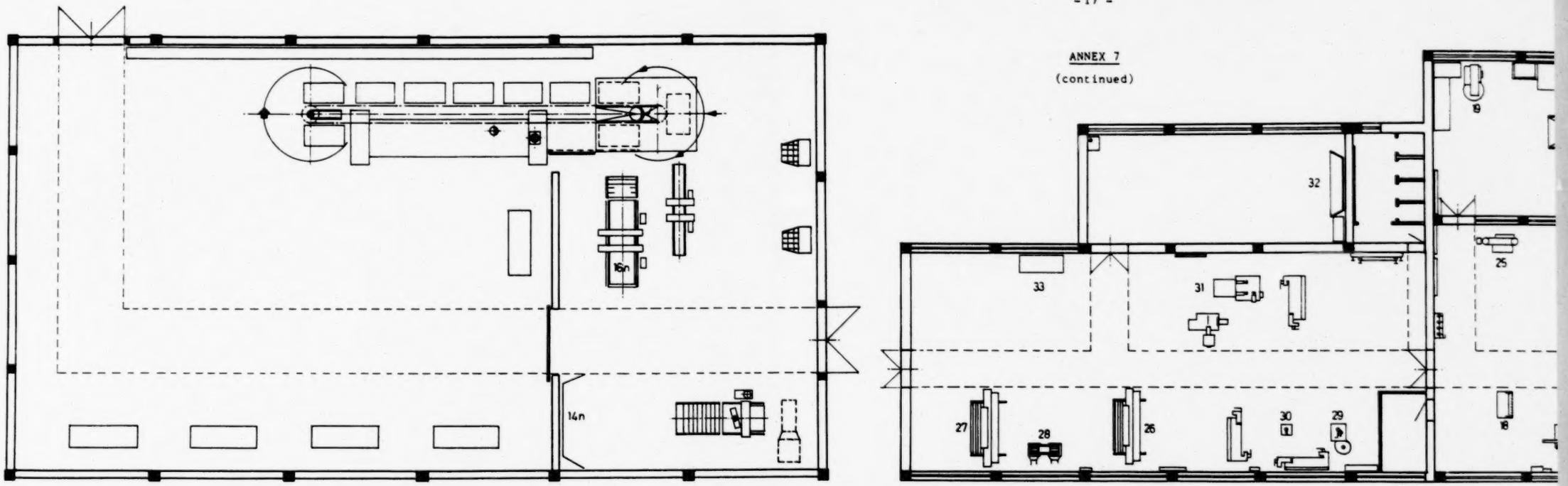
Legend for plant layout plan on following page

1. Shears for edging veneer packs
2. Veneer splicing machine
3. Cross-cutting circular saw
4. Radial arm saw
5. Single blade circular saw
6. Single blade circular saw
7. Table band-saw
8. Trimming saw
9. Surface planer
10. Thickness planer
11. Turning lathe
12. Router
13. Router with pneumatic attachment
14. Spindle moulder I
15. Spindle moulder II
16. Horizontal borer
17. Semi-automatic dowel hole borer
18. Dowel hole borer
19. Glue mixer
20. Glue spreader for surfaces
21. Veneering press
22. Double end tenoner
23. Edge bander (single side)
24. Contact sander
25. Oscillating sander
26. Belt sander
27. Belt sander
28. Disc sander
29. Edge lipping machine
30. Moulder
31. Assembly press for chairs
32. Spraying booth
33. Quality control station

14.n. Spraying booth

16.n. Lacquering line (curtain coater)

ANNEX 7
(continued)



WOODWORKING - FURNITURE PLANT - TECHNOLOGY

M = L : 100

ANNEX 7
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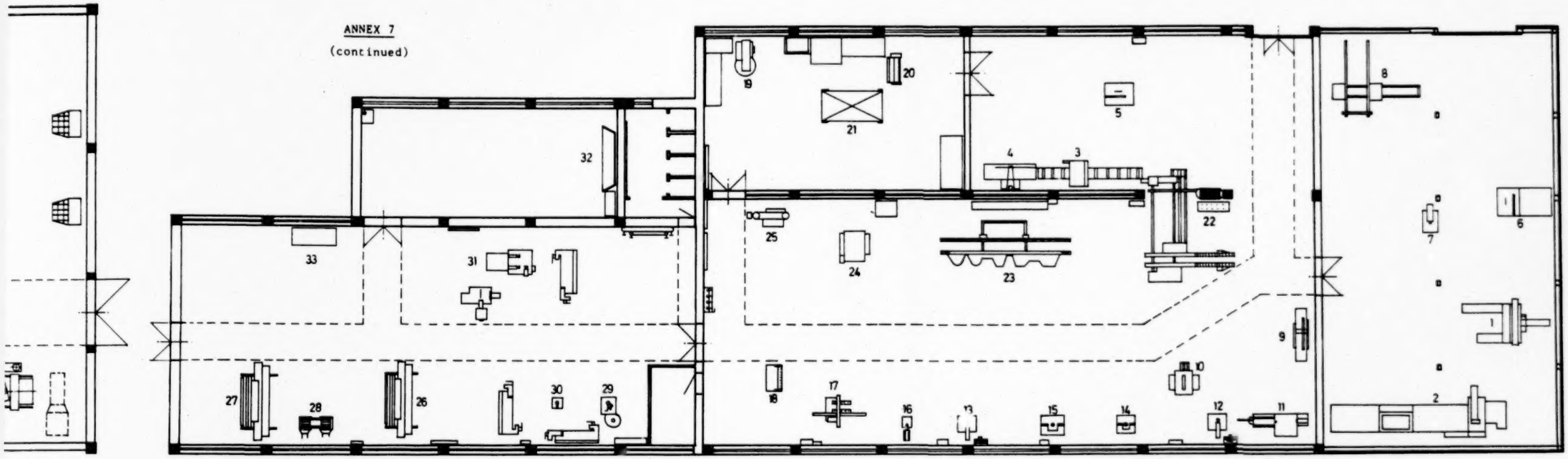

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PRODUCTION OF PREFABRICATED HOUSES*

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* The views expressed in this document are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO.

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TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
A. Typical features	2
B. The modular panel system	2
C. The large-size panel system	2
1. Basic principles	3
1.1 Main systems for prefabricated house elements	3
1.2 Construction material	4
2. Foundations	4
3. Fixing the walls	6
4. Delivery of components	9
5. Programme of walls	10
5.1 Durability	10
5.2 Strength	10
5.3 Basic programme of walls	11
5.3.1 Customary "CS" system - Outer walls "CS" system	11
5.3.2 Interior dividing walls	14
6. Standard prefabricated houses	15
6.1 Outer wall elements	15
6.2 Outer window and door structural elements	17
6.3 Front doors and windows	17
6.4 Interior dividing walls	17
6.5 Ceiling structure	19
7. Roof construction	19
8. Electric installations	19
9. Water connections	20
10. Laying flooring	20

INTRODUCTION

Wooden prefabricated houses can be of simple design and have general applications such as:

- temporary houses on devastated areas or big construction sites;
- permanent houses or service buildings as kindergardens, canteens, workshops, barracks, stores, nurseries (see fig. 1).

Prefabricated houses have been manufactured in Yugoslavia as permanent dwellings for over 20 years, and as temporary buildings about 30 years. The evolution went through different periods, from timber wall panels to modern wall construction where materials of highest quality are applied to spare wood.

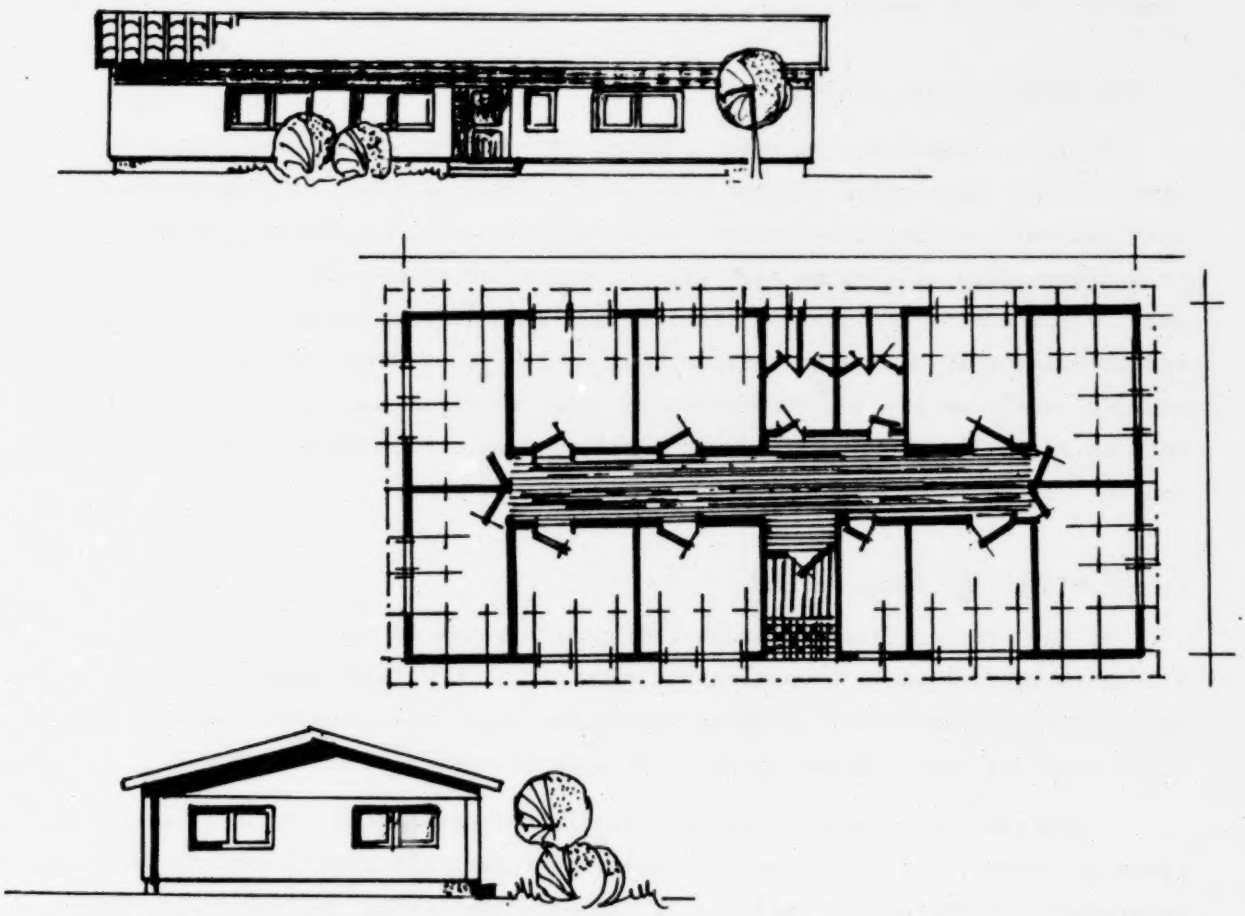


Fig. 1: Permanent houses or service buildings.

A. TYPICAL FEATURES

1. According to the needs, everybody wants to have a proper sized appartment or house. The shortest way to get a proper dwelling is still a prefabricated wooden house without having to worry about complicated design and planning problems. The average usable floor area of new dwellings varies considerably from less than 50 m^2 to approximately 100 m^2.

2. Each house has to have a basement, walls and a roof. It must furthermore have doors, windows and all other necessities (electric power, heating or cooling systems, water and sanitary installations).

3. For standard use, anyone can choose a model of any house. All houses are based on modular systems which are giving the possibility to erect any size to cover the needs.

B. THE MODULAR PANEL SYSTEM

Building components made for a modular panel system are constructed so that they can be handled without the use of cranes or other lifting devices. External wall panels, constructed under the modular panel system, are made in uniform sizes of 2560 mm high using a module as a unit width of measure (M). For elements, the minimum size is usually M 05 corresponding to 1600 mm and decreasing to M 01 which corresponds to 1200 mm. Partition walls are also made in panels or pre-cut components in order to facilitate electric installations as follows: (M) 11 (1200 mm), 13 (600 mm), 15 (260 mm), 16 (160 mm), and 17 (230 mm).

C. THE LARGE-SIZE PANEL SYSTEM

At the present time the large-size panel system is used to construct a large number of small houses on the same site. The large panel system is specially suitable for building operations where cranes are available, but it is doubtful that transportation over long distances is economic.

Prefabricated houses systems are simple and permanent: Our system consists of timber wall panels or combined timber particle board, mineral wood, paperboard and fasteners. All are of the same basic size but fulfilling different functions - as outside walls, doorways, windows and internal partitions. With these panels one can make almost any shape or type of building one requires.

If one is planning to build, versatile components can help one solve the problems. This system can help one to build:

- temporary homes,
- permanent houses,
- hospitals,
- kindergardens,
- nurseries,
- schools, and
- shopping areas.

A standard set of dimensions permits almost unlimited design possibilities. Buildings can be of all sizes and shapes. They are functional, attractive and individual too. A house, depending on size, can be erected in a few days.

The outside walls and roof can go up quickly, providing a dry weather-proof shell in which work can continue whatever the weather outside is.

All units are easy to handle. The purchaser can erect the building himself. Unskilled men need only an experienced leader to give explanations and are then able to erect a building. The building can be enlarged any time using additional components and one is sure that they will fit the existing structure.

1. BASIC PRINCIPLES

Each house has to have a basement, walls and a roof. It must furthermore have doors, windows and all other necessities (electric power, heating and cooling systems, water and sanitary installations). All these can be included based on a proper design of the basement and a proper use of the modular elements.

1.1 MAIN SYSTEMS FOR PREFABRICATED HOUSE ELEMENTS

Prefabricated houses are normally based on modular systems. A complete and rapid erection system is possible only if proper planning and its execution is assured. Many combinations exist using prefabricating for outer and interior walls, elements with already installed doors and windows, etc. Their combination makes possible the construction of a building of acceptable quality. Projects for basic houses have to provide all information if they

are to reach the goals set. Modular designs of houses are often based on the width of the element wall which are a timber frame with combinations of all kinds of materials to give the proper strength, thickness, thermal insulation, resistance, rigidity as well as a warm appearance.

1.2 CONSTRUCTION MATERIAL

Wood itself is a natural heat insulator because of its cellular structure. Air is the best insulator; hence the combination of double skinned wood panels plus an air space helps buildings to remain comfortable.

The advantage of wood is that it is one of the rare freely available materials. Everyone understands wood and knows how to work with it. Wood is easy to saw, nail and work with ordinary hand tools. Wood is strong, yet relatively light, needs only light foundations and is easily transported. Wood is handsome and does not rust and offers clean, quick, dry construction. Under certain circumstances it is possible to add extra insulation, the wall cavities can be lined with different insulating materials.

2. FOUNDATIONS

In prefabricated wooden housing the load bearing requirements differ from conventional constructions. It is vital with strip footings or raft foundations or a slab or bearing walls for the concrete poured on site to be smooth and level and for the setting out to provide ample edge fixing for the plates. Furthermore the fixings should be close to the edges of the slabs. All well designed projects should provide basement designs to meet all these needs. Details of various types of foundations are given in figure 2.

The concrete used in the basement must cover all the following standards, namely with respect to:

- the occupational safety,
- the panelling must be cleaned and moist before the concrete is poured,
- all construction iron must be cleaned of dirt, fatty constituents and rust,
- all auxiliary components must be ready for use,
- the concreting must be continuous (uninterrupted),

- at the end of the concreting process the area must be cleaned and prepared for the next erection step.

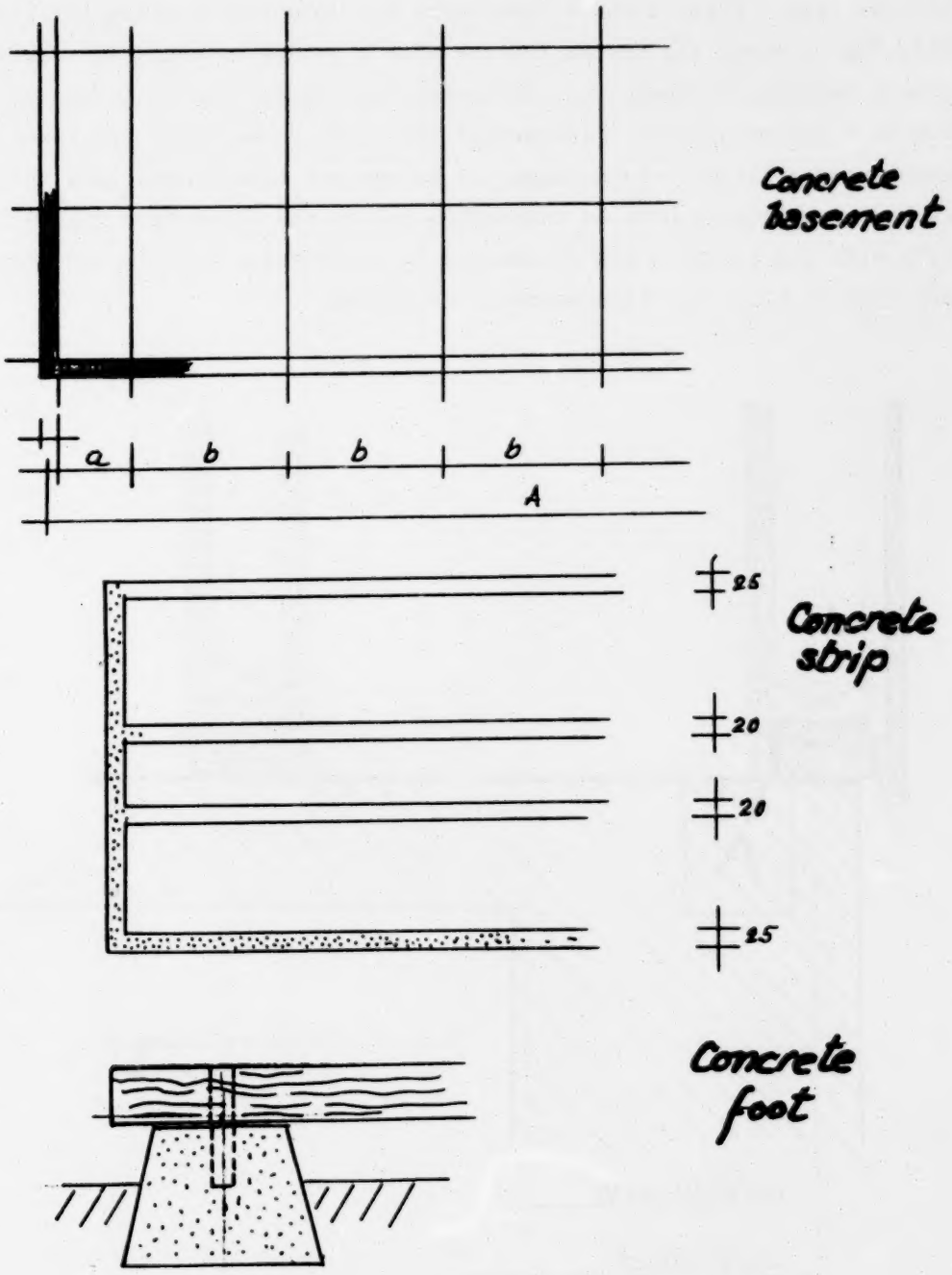


Fig. 2: Details of various types of foundations

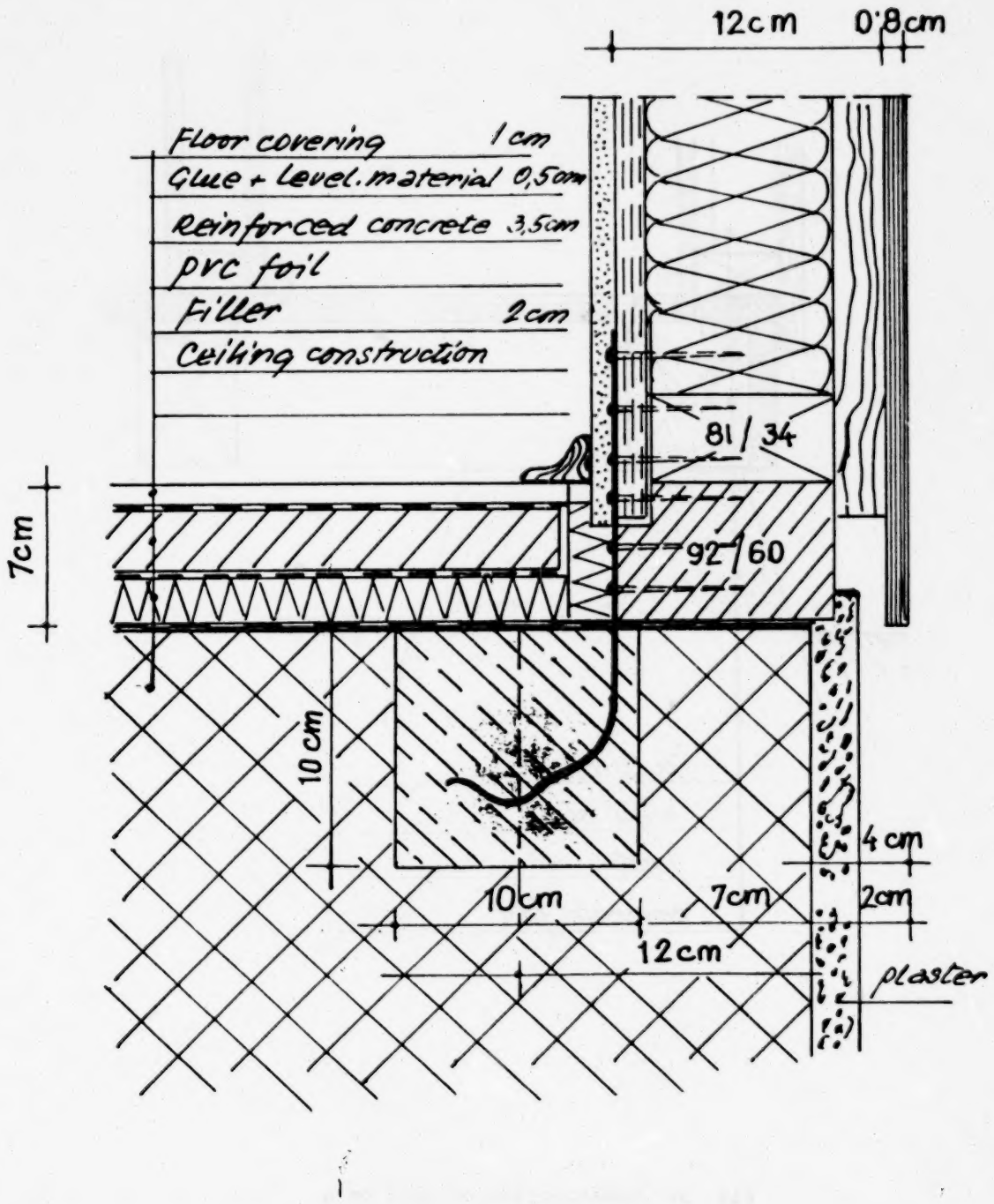


Fig. 4: Anchorage system for a wall on a cellar concrete slab.

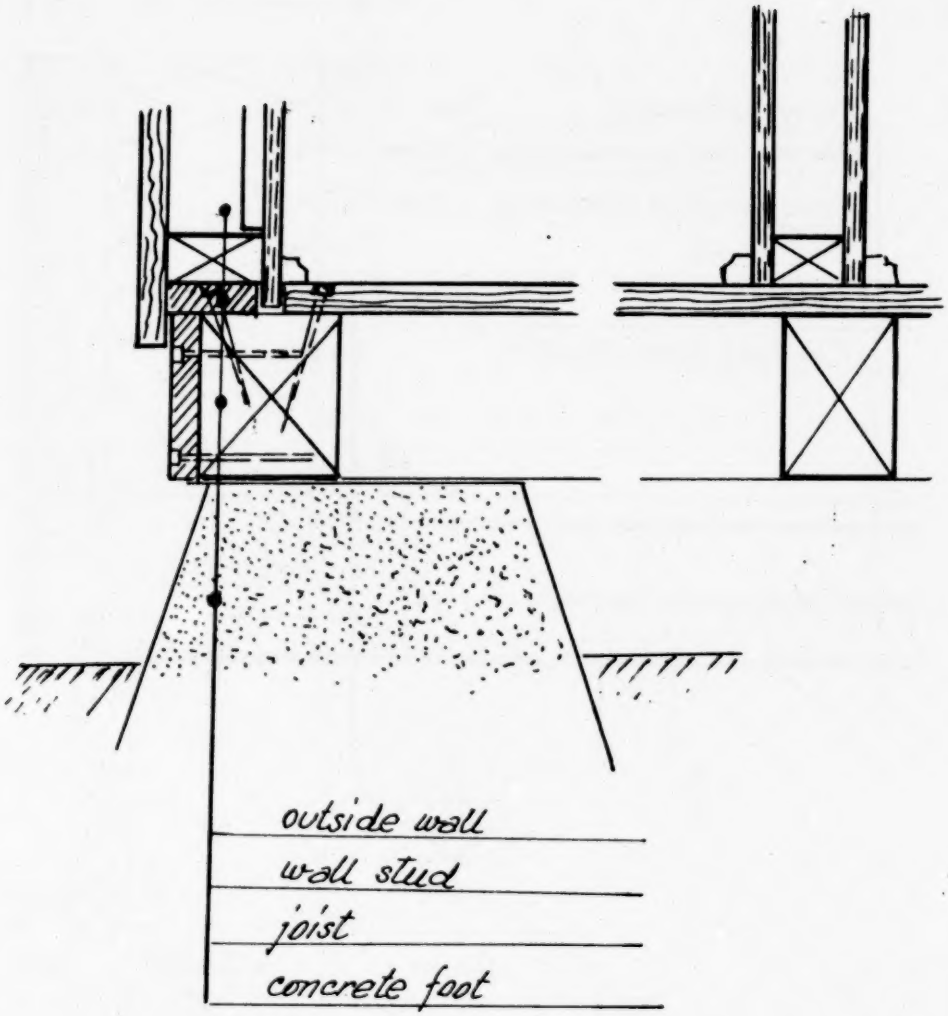


Fig. 5: Construction of wall on a concrete foot instead of a basement

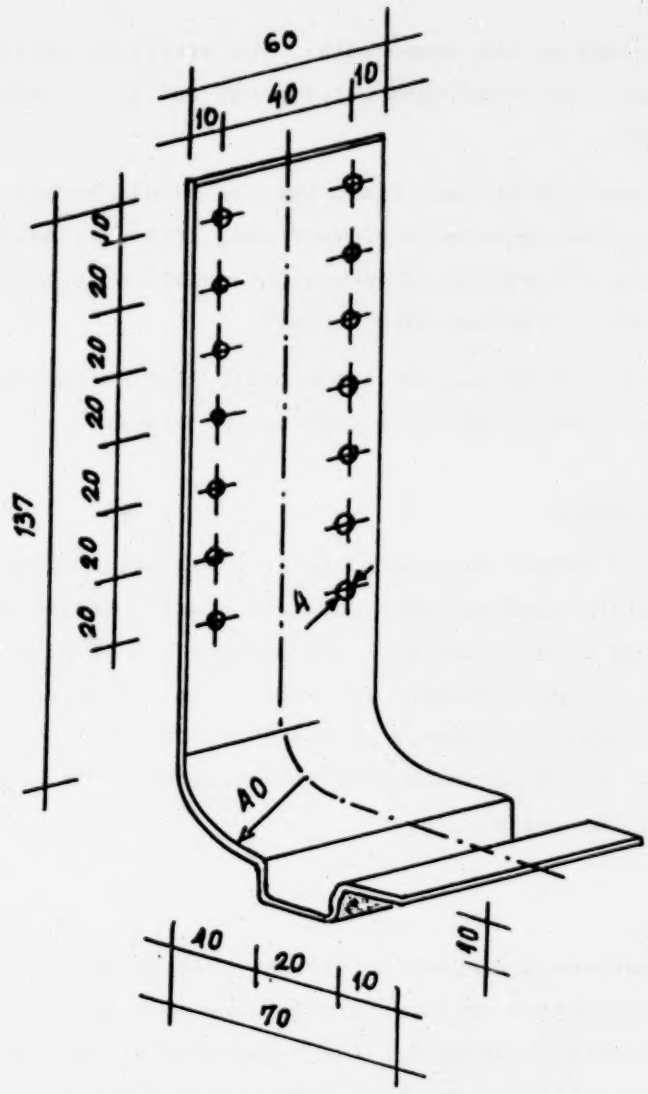


Fig. 6: Typical galvanized steel anchor

4. DELIVERY OF COMPONENTS

All components have to be delivered according to a programme to avoid delays. The delivery should be regulated to reduce the on-site storage of components to as short a period as possible and be made to storage sites in close proximity to the place of erection to avoid double handling. The components must be stored in such a way to avoid distortion by twisting or bowing or to work loose. Any cracking in structural components which causes a nail or a staple to "drag" renders the component unacceptable and these must be remade or replaced. The producer is normally responsible for

delivery and off-loading the components. The erection contractor has to stack the components to avoid them getting wet and it is important to use water-proof covers.

Trussed rafters can be laid flat, bearers should be placed to give a level support at close centers to prevent long term deformation. Alternatively if trusses are stored in an upright position, stacking should be carried out against a firm and safe support.

Walls normally can be stacked temporarily flat on bearers. For longer duration it is much better to stack them on "A" bearers.

5. PROGRAMME OF WALLS

In the type of houses we construct, the walls are of timber panels or a timber construction combined with particle board, mineral wool, paperboard all connected with fasteners. All materials must have the designated quality according to the standards in force. Fir and spruce sawn timber have to meet the required strength of standard JUS-D.C.1 041 for third quality wood which provides absolutely wholesome wood with the elasticity of the wood along the grain.

5.1 DURABILITY

Wood preservatives are added to provide protection to all parts of the wood susceptible to attack or deterioration and must be distributed in sufficient concentration throughout the vulnerable areas. Many methods of preservative application have been developed and all are intended to extend the service life of the wood.

All sawm timber is treated against attack by insects or fungi by a non-pressure dipping process with water-soluble chemicals which are not poisonous to animals or people and will not be washed out by rain, is not oily and can be painted over.

5.2 STRENGTH

The building is designed to stand up to the maximum expected winds and weather conditions and is a safe, reliable and permanent structure. All components have evolved as a result of exposure and strength tests over several years before the system was accepted as a standard.

5.3 BASIC PROGRAMME OF WALLS

The knowledge of the difference between a load bearing and a non load bearing wall is crucial before beginning any wall construction. Load bearing walls carry part of the weight of the house; non load bearing walls do not. All exterior walls that run perpendicular to the ceiling and floor joists are bearing. Other walls throughout the house serve simply to divide it into rooms are non-bearing walls.

5.3.1 CUSTOMARY "CS" SYSTEM - OUTER WALLS "CS" SYSTEM

The wall is composed of a framework of sawnwood. The outer walls are load bearing and based on a 1,000 mm module and 110 mm thick. The composition of the outer structural element from the outer to the inner face is as follows (see fig.7):

- shiplap board	20 mm
- pergamin paperboard	1 mm
- wood lath	36/75 mm
- particle board	13 mm

Shiplap board can be replaced by asbestos cement board. Pergamin paperboard is used as an isolation against outside moisture (rain). It is possible to fill the space between the outside and inside boards with mineral wood to increase thermal insulation. Details of a corner connection are given in figure 8.

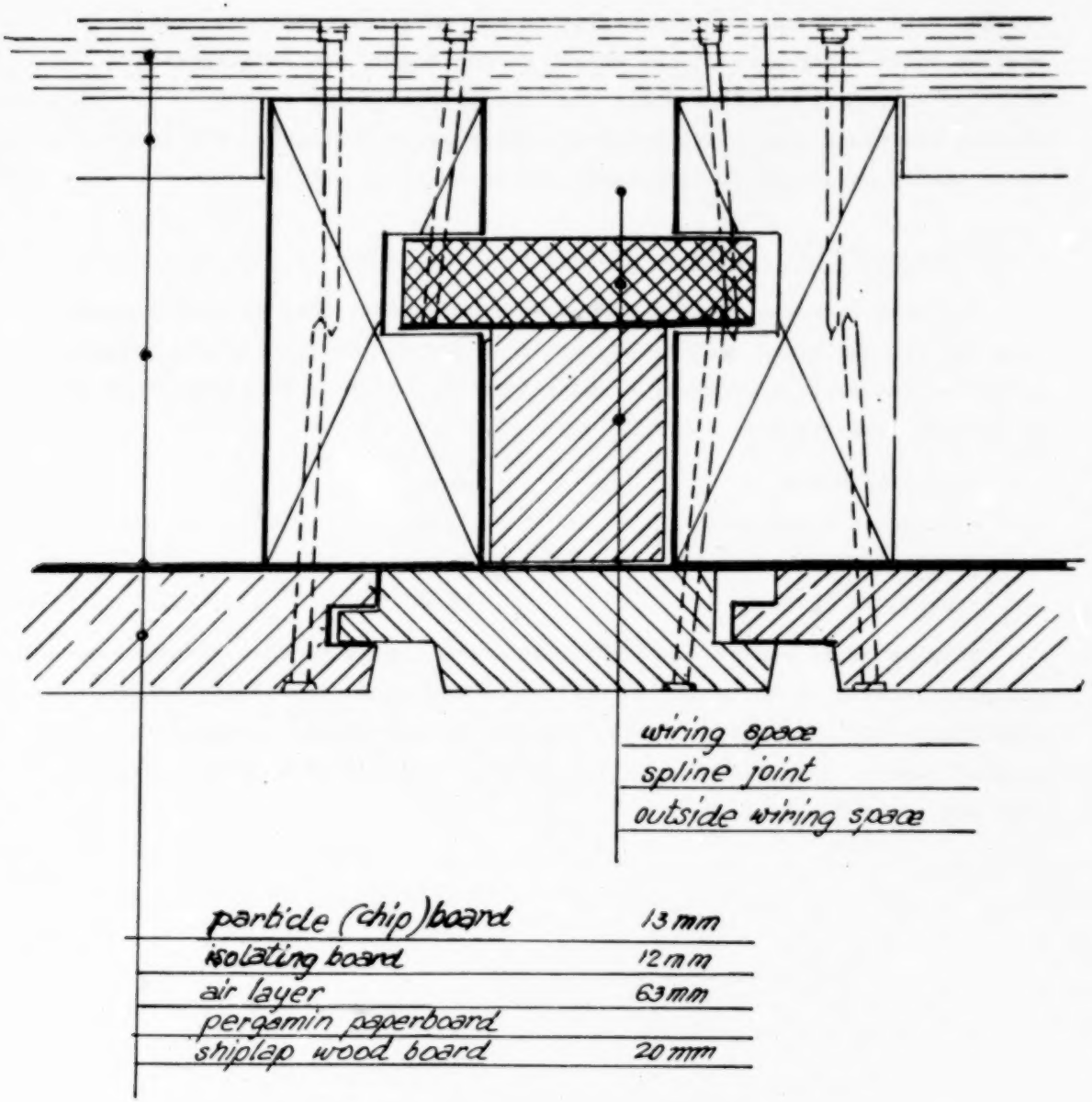


Fig. 7: Typical connection between two outside (load bearing) wall elements.

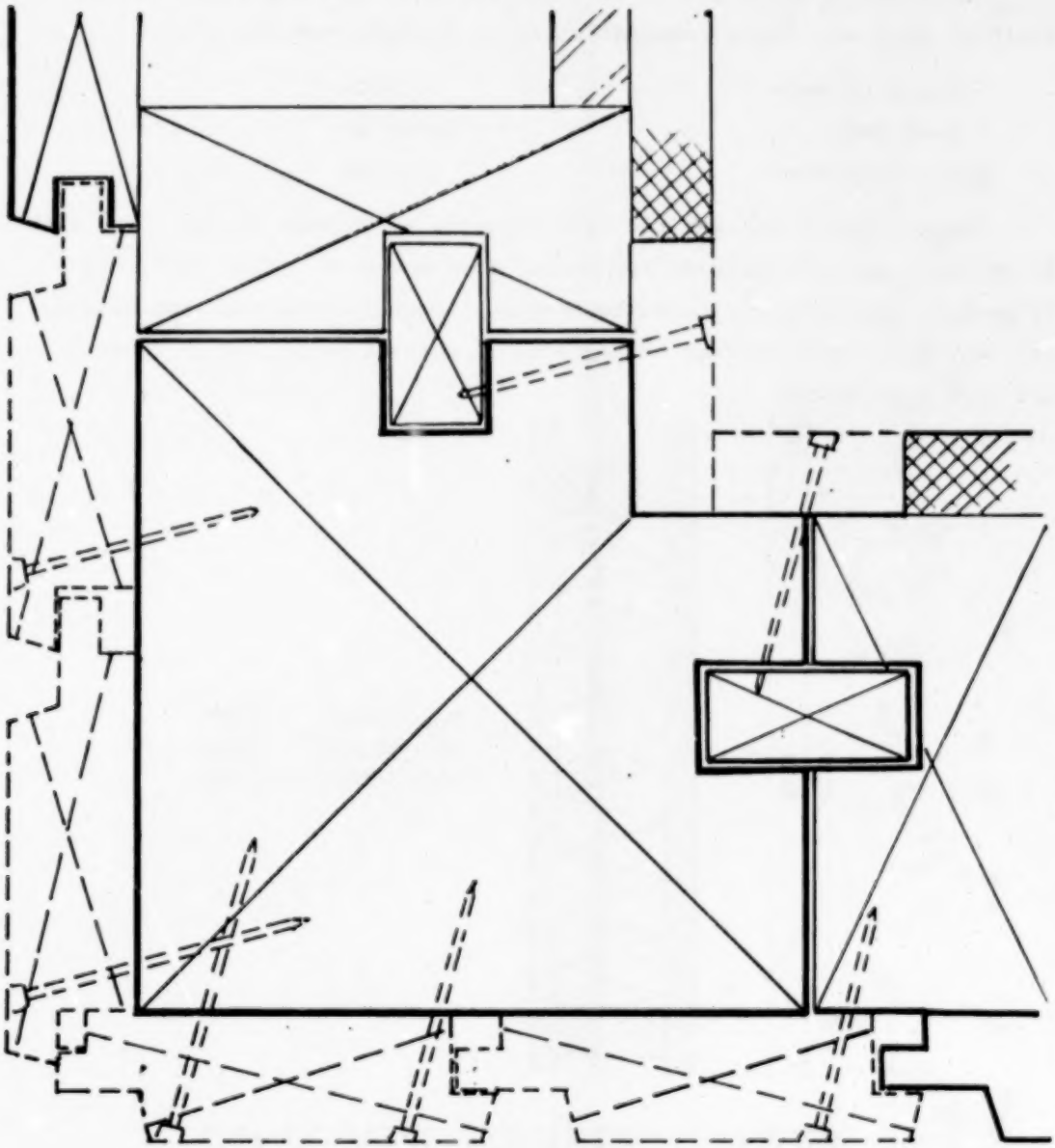


Fig. 8: Details of a corner connection.

5.3.2 INTERIOR DIVIDING WALLS

The dividing walls are 76 mm thick and they have the same modular width of 1000 mm. Their composition is as follows (see fig. 9):

- particle board	13 mm
- wood lath	35/50 mm
- particle board	13 mm

The connection between two wall elements is through spline joint with 30 mm empty space to provide for normal wood movement. This empty space is used to pass electric conduits through. Corner connectors are similar in connection to the corner connections of outside walls though these are more complicated.

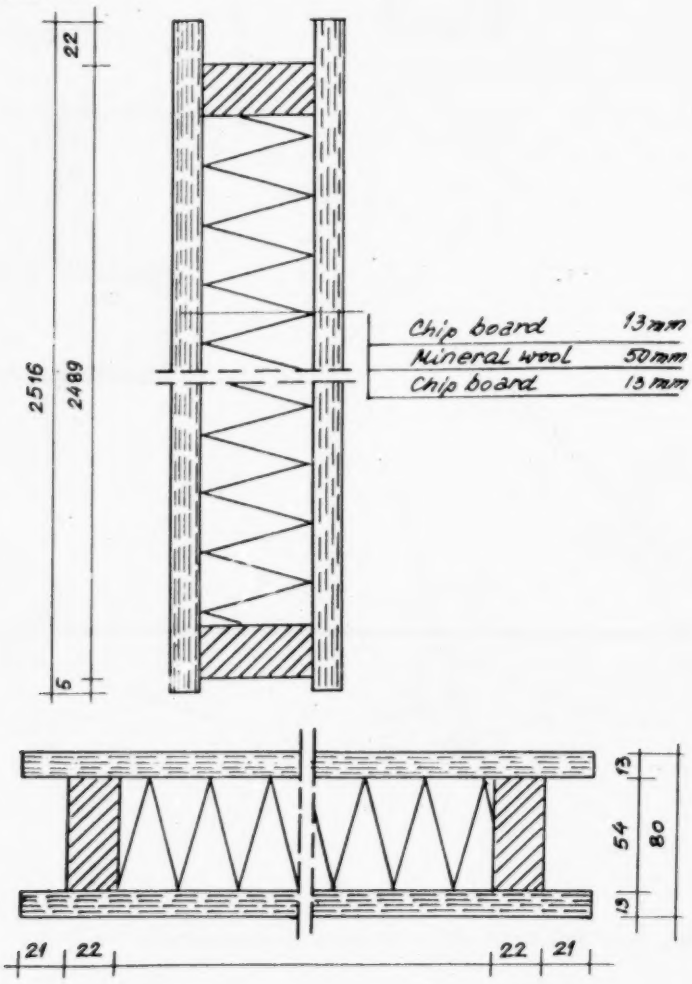


Fig. 9: Non load bearing interior dividing walls.

6. STANDARD PREFABRICATED HOUSES

6.1 OUTER WALL ELEMENTS

The wall is composed of a framework of sawnwood. Load bearing or non load bearing walls have the same basic framework, but load bearing walls are more complete because their function is more important.

Sawnwood for the wall framing is characterized by its stiffness, nail holding ability and freedom from warp. In Yugoslavia (and Europe) the most commonly used wood species includes spruce, fir, pine and larch.

The outer walls are normally (for european standards) 130 mm thick and have a width of 1200 mm module, or 600 mm, and are of the load bearing type. The height of these elements is 2560 mm.

The composition of the outer structural element from the outer to the inner faces is as follows (see fig. 10):

- straight asbestos-cement board	8 mm (JUS B.C.4.010)
- wood laths	22/60 mm
- pergamin paperboard	1 mm (JUS U.M.3.220)
- air layer	22-18 mm
- solid mineral wood	60 mm (JUS U.M.9.015)
- aluminium foil	0.04 mm
- particle board	13 mm
- gypsum board	10 mm

The framework of the elements forms a wooden frame of 100 x 44 mm cross-section with spacing which serves as a support for the asbestos cement board, the particle board and the gypsum (plaster) board.

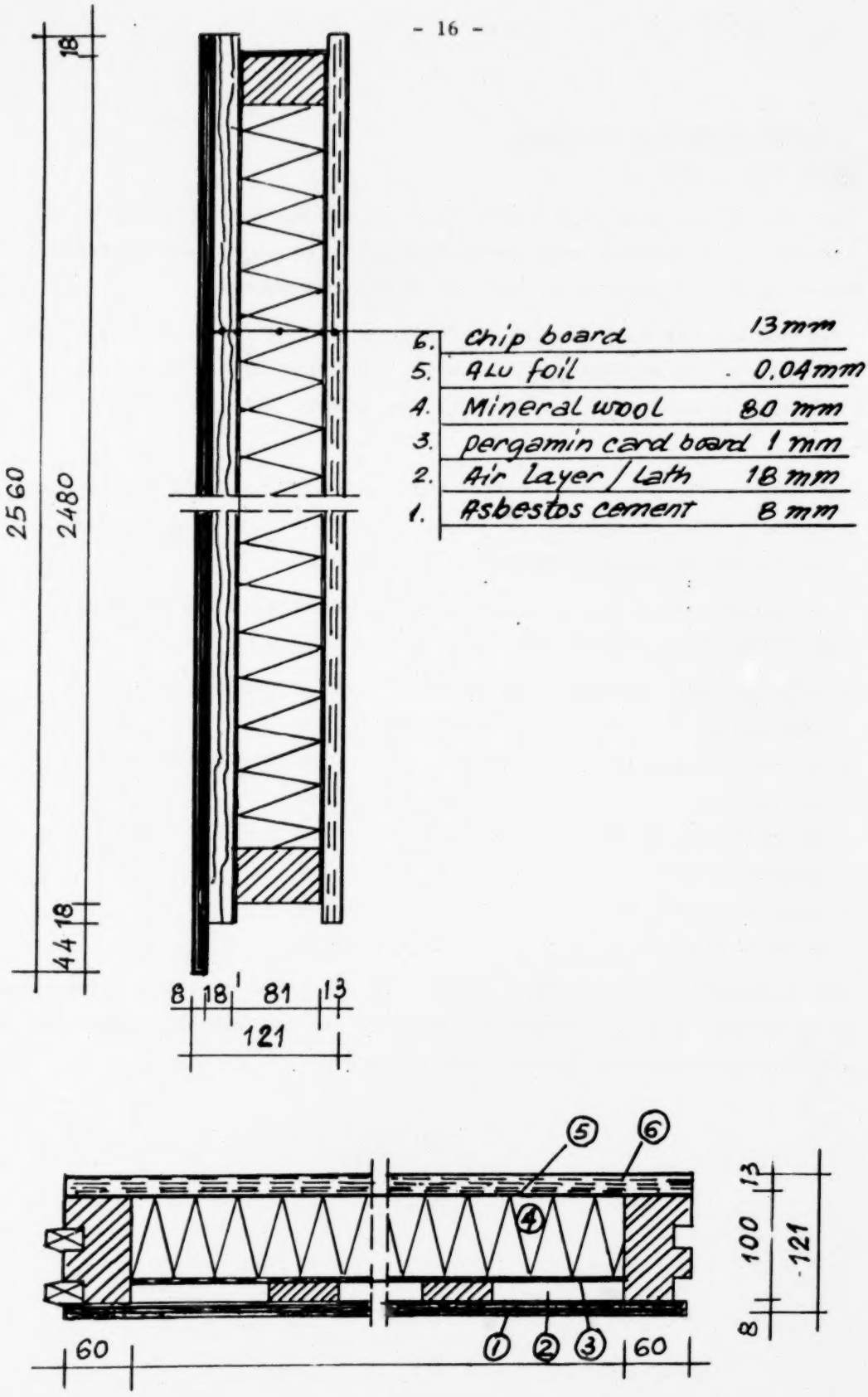


Fig. 10: Outer (load bearing) wall element.

6.2 OUTER WINDOW AND DOOR STRUCTURAL ELEMENTS

The structural element comprising the window is similar to the outer solid structural element. The thicknesses are 130 mm and the width 1200 mm or 950 mm. The wall openings are provided for installing transparent glass windows and balcony doors. Usually, windows and walls are shipped separately. Windows are built in the time of the erection of the house.

The windows are produced of high quality solid wood. The number of glass panes depends on the client's wishes.

6.3 FRONT DOORS AND WINDOWS

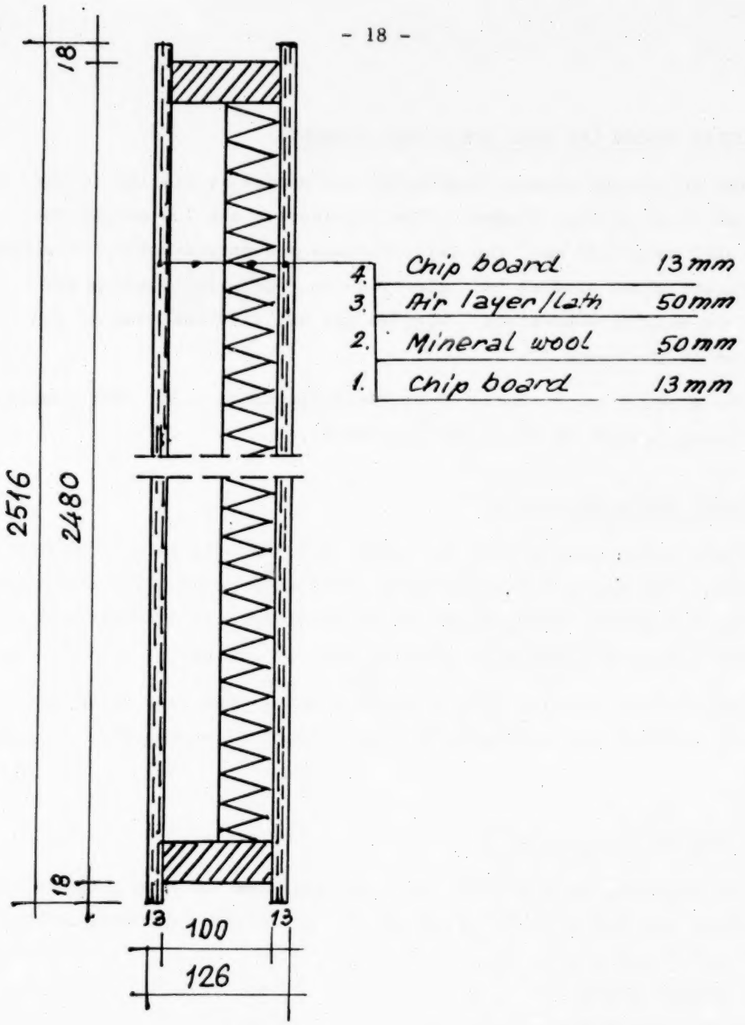
Front doors are provided for subsequent assembly into front door elements. The door wings are made of first class wood. The wings have openings for glass. Measurement of the front door is standardized, i.e. the door has to be compatible with the modular system.

The windows are also made of quality wood. The wood structure is visible, windows are standardized by the client often chooses the actual type.

6.4 INTERIOR DIVIDING WALLS

The dividing walls are 100 mm thick and have the same modular width of 1200 mm and 600 mm. The cross section of interior dividing walls is (see figs. 9 and 11):

- gypsum board 10 mm
- particle board 13 mm
- mineral wool 50 mm
- particle board 13 mm
- gypsum board 10 mm



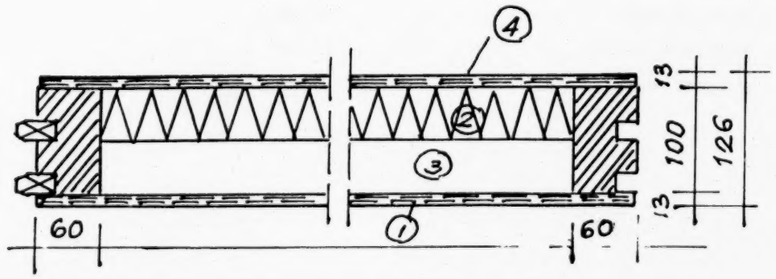


Fig. 11: Interior load bearing wall.

6.5 CEILING STRUCTURE

The ceiling structure is formed of a wood frame of cross section 20 x 80 mm and spacers.

The ceiling structure comprises:

- pergamin paperboard	1 mm
- mineral wool	80 mm
- aluminium foil	0,04 mm
- particle board	13 mm
- gypsum board	10 mm

The installation of the gypsum board on the faces of structural elements takes place on site. The frame structure of dividing walls is formed on a wooden frame of cross section 54 x 44 mm according to the JUS standard.

7. ROOF CONSTRUCTION

Buildings should be designed as a whole with attention being paid to providing support for the roof at an early stage of construction.

Timber remains the most suitable material for the construction of small or big roofs because of its durability, ease of working and simplicity of jointing. Trusses are connected by metal connector plates pushed into the wooden parts mechanically.

When designing a roof all loads must be taken into consideration (snow, wind, roof covering); the actual construction and covering depend on local town planning requirements. Producers of prefabricated wooden houses develop several forms of roofs and pitches to meet various requirements. A stress analysis must be made for each roof.

8. ELECTRIC INSTALLATIONS

The electrical energy is transmitted in the house by cables meeting the standards. These cables have to be inserted into "tuboflex tubes" which are located in the walls with connectors or distributors. In installing, all passages through the floors or walls have to be carefully checked against any damage.

9. WATER CONNECTIONS

In designing the dwelling houses it is very important where and how to install the water system. Water pipes have to be connected to the source (or water line, or the site's own well) and led to the house through galvanized pipes. Water installations are provided through the floor or through the walls proper completely isolated. The sanitary wall must be built out of bricks.

All inside water installation coming from outside are led horizontally in the cellar or basement to all vertical connections. All installations are of galvanized steel with proper fittings.

All tasks have to be carried out by professional plumbers according to plans and laws applicable where the house is to be assembled. All materials have to be of first class quality and the complete system has to be attested and tested before being accepted.

In certain climates heating and hot water installations are important for each house. Prefabricated houses which are based on timber frame construction have low thermal capacity with fast response to heat input. Timber construction is compatible with heating systems which can respond rapidly to heat demand. By using small units individual controls for each room or space, heating or cooling do not pose any problem.

10. LAYING FLOORING

The type of floor to be laid depends on the project. There exist different methods and different types of floor. Before beginning application, the subfloor has to be checked to make sure it is clean and well nailed to the joist to prevent it from squeaking later. By laying a heavy building paper or deadening felt, noise and cold and be slightly lessened.

Wood is the most standard flooring used. It is milled in three general styles: strip flooring, plank flooring and block flooring.

Strip and plank flooring can be applied to sleepers (wooden strips) over concrete floors or to board or plywood subflooring. Because strips or planks should be laid at right angles to the floor joist, board sub-

flooring is nailed to the joists at a 45^{o} angle. For plywood subflooring, strips or planks can be applied in either direction.

Block flooring is best applied directly to concrete floors (no sleepers are needed for its application), but it can also be laid on plywood subflooring.

All other inside finishing must be done according to the plans. All materials must meet the different standards.

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